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Recent technological advancements, V2G systems, and its implications for increased adoption and scalability using Artificial Intelligence

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Abstract
The slow and steady transition in the direction of cleaner and green energy sources warrant the application of electric vehicles (EVs) as the mainstream platform for transportation. This investigation highlighted a few significant challenges, which include extreme burden on EV batteries at the time of V2G, the absence of suitable bidirectional charging infrastructure, technological complexities and the likelihood of V2G practices that may prove to be uneconomical and unscheduled. Contemporary research and reports from international agencies are reviewed in order to present probable solutions to the emerging bottlenecks and identify the regions that may require additional research. V2G could hold immense promises when it comes to clean mobility especially with the emergence of novel V2G technologies, however, significant collaboration, funding, and technology maturation are the basic requirements for the success of any relevant schemes.

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Keywords: Electric Vehicle, Vehicle to Grid, V2G, charging, charging infrastructure, technology, EV

Introduction

Due to the emergence of serious concerns pertaining to global warming and the impending energy crisis owing to fast depleting fossil fuel reserves and the consequent strive to cut down fuel consumption and carbon emission, electric vehicles (EV) are now being paid greater attention all across the globe (Zheng & Jian, 2016) [27]. The increasing popularity of electric vehicles have resulted in an urgent demand to take care of the stress put on grids by the EVs as they access the grid frequently and in an erratic manner (Cheng, *et al*., 2021) [1]. The application of vehicle-to-grid (V2G) technology holds a lot of promise when it comes to optimization of the power demand, determination of the variation in load, and enhancement of the sustainability of smart grids (Mojumder, Antara, Md. Hasanuzzaman, Alamri, & Alsharef, 2022) [12]. Nevertheless, there are no compilation of papers presenting comprehensive studies pertaining to types of V2G and their operations, types of EV being sold in the market and their current ratings, V2G business model and the relevant policies, and most importantly the difficulties faced in V2G implementation and the existing policies and procedures that can be used to cope with these problems. This work presents a scrutiny into the present technological developments in V2G. The research starts with an overview of the V2G technology then discusses the challenges associated with V2G on the power grid and vehicle batteries; the development of new technologies as their possible solutions and finally their evaluation.

Overview and Background of V2G Technology

According to the International Energy Agency (IEA) for a net zero scenario exist, by 2030 the battery storage capacity at the global level must increase at least 17x the 2020 capacity. However, the IEA makes no comments regarding whether this storage need to be mobile or stationary. The fast expansion of stationary capacity is happening in the form of large-scale systems for energy storage. Nevertheless, the dimension of this growth is not that impressive when compared to the battery growth that expected to come from the proliferation of electric vehicles across the world. Hence it is more sensible to make better utilization of this rapidly expanding form of energy storage. (Tahir & Gannatti, 2023) [17].

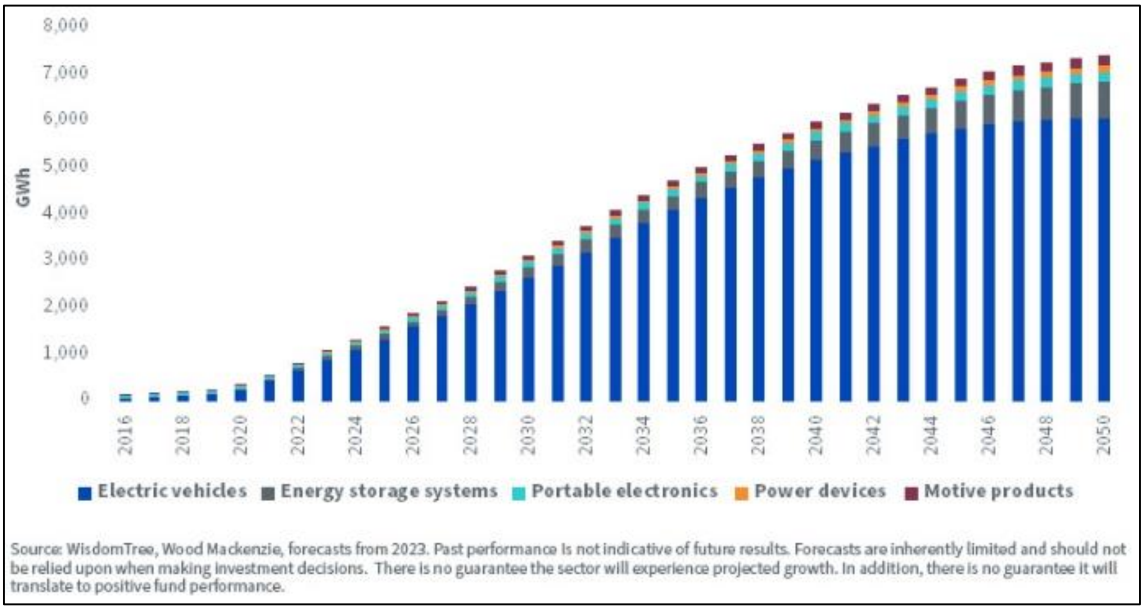

Fig 1: Total Storage Demand by Sector

These EVs draw a significant amount of power from the grid but not all of it is used. A part of the energy remains stored for future use and sometimes may even remain unused. It is believed that energy storage will be most effective if it remains well-distributed. The whole reason behind energy storage is handling the sporadic nature of renewable energy. For more efficient management of demand and supply and reduction of transmission losses, it is better to have a well-distributed energy storage across the grid. Obviously electric vehicles are the logical choice as they are distributed across the grid by virtue of being parked close to the vehicle owners (Tahir & Gannatti, 2023) [17].

The transformative phase in the alliance between Electric Vehicles and power grids is denoted and facilitated by the technology called Vehicle-to-grid (V2G). It is an advanced system that lets the electric vehicles draw energy from the grid for charging and at the same time also allows the EV to push the stored energy in the EV batteries back into the grid when required and necessary. The technology is frequently associated with bidirectional charging, gives rise to a dynamic relationship in which the EVs function like a distributed source of energy benefiting not only the electric vehicle owners but also imparting stability to the grid (Servotech Power, 2023) [14]. Despite the inadequacies that prevail in terms of EV infrastructure, the V2G technology promises such things as expansion of the grid not through construction of power plants but through utilities, power backup for the consumers and income from the electric car which virtually makes the ownership of the EV free (Wenzel, 2019) [25].

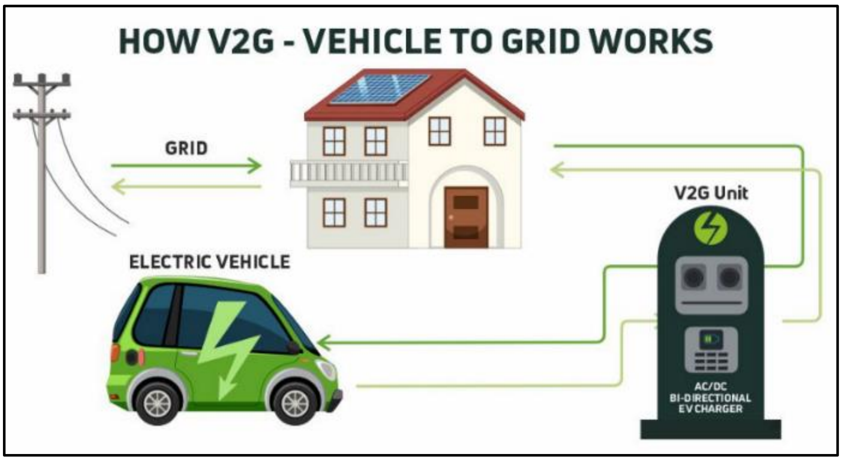

Fig 2: V2G - The Process (Servotech Power, 2023) [14]

Benefits of V2G Technology

V2G is being considered by the utilities as a technique that can help reinforce the grid while bringing down the cost of operation and fulfilling renewable-energy (RE) goals through the utilization of the batteries in these vehicles which usually spend over 90% of their lives idle and off the road (Wenzel, 2019) [25]. Several advantages are associated with electric vehicles. They are efficient, rechargeable at the discretion of the owner, free of carbon emission and are remarkable means of transportation. This technology allows interaction of the plug-in electric vehicles with the power grids and makes it possible for these EVs to supply the excess energy, stored in their batteries, back to the grids (Hive Power, 2021) [7]. The key benefits of adopting the V2G technology are the following.

1. Renewable Energy Integration: V2G makes the

integration of RE sources into the grid, possible (Ghofrani, *et al*., 2016) [5]. The excess energy that is generated from renewable sources such as wind energy or solar power can be stored by the EVs and supplied, when necessary, thus maintaining an energy mix that is not only cleaner but also more sustainable and, in the process, cutting down the overall emission of greenhouse gases and enhancing environmental support (Servotech Power, 2023) [14]. This ground-breaking technology allows EVs to act as giant mobile electricity storage devices (Kumar, Revolutionizing Energy Distribution: Exploring the Potential of Vehicle-to-Grid (V2G) Technology, 2023) [10].

2. Virtual Power Plant (VPP): By performing like a decentralized energy system, V2G technology effectively coordinates a huge number of EVs. During peak hours when the demand is mounting, it supplies power. At times of low or moderate demand, it charges and, in the process, balances the grid (Kumar, EVs as Virtual Power Plants (VPP), 2023) [10]. This orchestration is referred to as the Virtual Power Plant or VPP. It aggregates flexibility of resources from the customers' side, presents to the customers a way for effectively participating in the electricity market, and offers to the market an array of variable technologies and accommodating services and a vital aspect is that VPPs can provide services to the EV charging stations (Wang, Guo, Yu, & Liang, 2022) [23]. In sharp contrast to the traditional power plants, cloud-based software is used by VPPs for controlling a huge number of battery systems for creating a storage system or practically a large-scale generator and for combining different energy resources such as batteries, EVs, and solar panels (Servotech Power, 2023) [14].
3. Voltage Support: Integration of electric vehicles into the grid on a large-scale will affect the grid voltage in a significant manner and EVs will be able to provide the baseload for a short period of time which in turn will improve the stability of the grid. (Ravi, Aziz, & , 2022). Electric vehicles that are equipped with V2G capability will be able to provide voltage support to the grid and ensure that a steady and constant level of voltage is maintained (Servotech Power, 2023) [14]. Stability can be ensured though the fabrication of V2G systems that are proficient in housing various charging algorithms and acclimatizing to diverse voltage levels of EV (Umair, *et al*., 2023). V2G mode of operation using storage and supply services can improve transient voltage stability of distribution network (Khalid, Lin, Zhuo, Kumar, & Rafique, 2015) [9].
4. Backup Power: In case of a power outage or any other emergency, V2G will be able to provide an important backup power source (Umair, *et al*., 2023). Providing grid support is just one of the several beneficial aspects of bidirectional EV chargers that are used to empower V2G systems. These devices are extremely powerful and comprise of power inverters. Majority if these novel bidirectional chargers also have the capacity to provide backup power in the event of occurrence of such incidents as a blackout or any other emergency. Powering a house independently of the grid using a bidirectional inverter, however, requires islanding in the first place. Islanding is a process that involves the isolation of the inverter from the grid network, known as (Servotech Power, 2023) [14]. Electric vehicles can easily go through this process and prove beneficial.
5. Grid Stabilization: Besides having the potential to address the storage issue, V2G also has the ability to help in imparting stability to the energy system (Sinha, 2023). By virtue of application of V2G electric vehicles can easily use bidirectional energy flow technology to supply back to the grid, the accumulated energy, as and when required. This technology allows EVs to be charged during hours when electricity demand is low or off-peak hours and during peak hours when there is high electricity demand these EVs can be discharged and the power sent back to the gr0id. This entire process facilitates smoothing out of fluctuations faced by the grid from time to time thus improving the overall stability of the grid (Umair, *et al*., 2023). This capability can be a potential grid stabilizer that acts through striking a balance between demand fluctuations and supply inconsistencies, especially during peak hours when the demand for electricity starts changing rapidly, or in times of emergencies (Servotech Power, 2023) [14]. Despite being in the budding stage, the grid stabilization consideration can turn out to a game changer albeit proper implementation (Sinha, 2023).

Nevertheless, there are several serious challenges that this novel technology faces.

Challenges of V2G Technology

While V2G appears as one of the best possible solutions for the problems of pollution, global warming, mobility and conservation of fossil fuels, the V2G technology can be propelled into the mainstream only after the necessary standardized protocols and adequate regulatory support can be put together, in place to provide support to the system. These efforts are necessary to make sure that there exists interoperability between different vehicles, proper and adequate charging infrastructure is in place, and necessary incentives are provided for integration of V2G using transparent and unambiguous tariff structures as well as regulations pertaining to grid access. For EV owners V2G participation can be simplified by augmenting across homes, public spaces, and workplaces charging infrastructure that is compatible with V2G. Stakeholders' collaborations is conducive to fostering technological advancement, while wider adoption can be fostered through showcasing V2G advantages using large-scale demonstration projects. Incessant Research and Development is the key to V2G technology enhancement, optimization of energy management, and ensuring stability of the grid for its mainstream incorporation (Servotech Power, 2023) [14].

Technological Developments & Challenges – An Evaluation

Sizeable charging infrastructure for charging and discharging EVs is essential for the commercial deployment of EVs (Shariff, Iqbal, Alam, & Ahmad, 2019). Vehicle to Grid technology came into existence as a novel and emerging technology that allows the usage of a large number of EVs as both a load and an energy storage system capable of supporting the grid. The V2G charging technology is mutually beneficial for both energy companies and consumers and is on the verge of wider acceptance due to the rapid adoption of EVs across the world. Nevertheless, EV charging in an uncoordinated manner can have crucial impact on the power system. This article scrutinizes some of the major contemporary developments in V2G technology.

Battery Technology

Depending on the type of signals, such as energy production or consumption nearby, an EV battery can be discharged using the V2G technology. This technology powers bi-directional charging, thereby creating the possibility of charging the EV battery and then taking the energy stored inside these batteries and pushing it back to the power grid (Vitra Global, 2023). Despite several merits a key concern regarding the large-scale use of V2G technology has been the impact that V2G operations have on the Lithium-ion batteries degradation, which is central to both EV and V2G operations. Recent studies show that additional cycles of EV batteries for discharging to the power grid, irrespective of constant power, has proved to be detrimental to their batteries (Uddin, Dubarry, & Glick, 2018).

Even at constant power, additional cycling for discharging vehicle batteries to the power grid can prove to have a negative impact on cell performance. Due to additional use, these battery packs could witness shortened lifetime for vehicle use and their lives could reduce to less than 5 years. On the contrary, there is no significant impact of postponing the charging with the purpose of reducing the impact on the power grid. This, however, is true at room temperature, but can actually be substantial in climates that are warmer (Dubarry, Matthieu; Devie, Arnaud; McKenzie, Katherine;, 2017).

Smart Grid

Electricity networks that make use of software, sensors and digital technologies, for the purpose of better real-time matching of the demand and supply of electricity are called smart grids. While it will help to maintain the stability of the grid and increase its reliability it will also play a big part in better cost rationalization (IEA, 2023). The modernized electrical power grid that allows communication between the utility and the consumers making use of computer-based remote control and automation is referred to as the Smart Grid. It helps to enhance the sustainability, efficiency, and reliability of the power supply (Ghofrani, *et al*., 2016) [5].

The smart grid came into being as an outcome of technological development and hence was not a feature of the existing power grid infrastructure which means that the grid infrastructure needs to be retrofitted. However, this retrofitting could be a big challenge and so one of the biggest hurdles in technological advancement of V2G system. It is also obvious that V2G implementation would entail a significant amount of investment as improvement and upgradation of hardware and software in the grid system will translate into major expenditure (Ghofrani, *et al*., 2016) [5]. The required investment in smart grids is at least double the present amount and needs to happen through to 2030 for most countries around the world, to be on track to achieve the one of the stated key objectives of their governments - attaining Net Zero Emissions by 2050 (NZE). It is, especially relevant for emerging market as well as developing economies (EMDEs) (IEA, 2023). Intelligent interactions between the aggregators, smart grid, and EVs has the potential to bring various benefits to all the parties involved, for instance, enhanced safety and better reliability for the smart gird, higher profits for the aggregators, along with greater self-benefit for EV customers (Wang, Liu, Du, & Kong, 2016) [24].

Smart Charging Algorithms

Electric vehicles have started receiving higher attention all across the world due to serious concerns pertaining to global warming and an impending energy crisis that would be the obvious outcome of the fast-depleting fossil fuels. The modern world will eventually run out of non-renewable energy resources. The biggest aspect of EVs that is also an impediment in their faster adoption is the need to charge these EVs on a periodic basis and the lack of adequate charging infrastructure, especially in the emerging countries. The power grid will have to bear the strain. It has been observed that ungainly large-scale charging of EVs is most likely to jeopardize both the security and stability of the power grid. With the aim of alleviating the adverse impact on the grid, it is necessary to employ those algorithms that take into account the priority of dynamic charging within the framework of smart grid (Zheng & Jian, 2016) [27]. The level of voltage rendered is different for different EVs and demands the presence of separate charging and discharging algorithms that will help to handle the load demand.

EVs have a strong influence on the power grid profile. The impact is of a much higher degree compared to the traditional loads. Output voltages that remain unbalanced may lead to voltage instability, system imbalances, reliability issues, and altered reserve margins (Mojumder, Antara, Md. Hasanuzzaman, Alamri, & Alsharef, 2022) [12]. In sharp contrast to V1G charging, another name for regular smart charging, V2G takes a further step by pushing power back to the grid. Besides enabling the charging of electric cars in a manner that allows the charging power to be increased and decreased on demand, V2G also makes it possible for the charged power to be pushed back to the electric grid, temporarily, from car batteries with the purpose of balancing the variations that occur in energy production and consumption (CORINEX, 2024) [2].

EVs access the grid frequently but in an irregular manner. This places a lot of stress on the grids and the pressure has been mounting with the growing popularity of electric vehicles (EV), which has created an urgent demand for finding a solution to this problem. Conventional fast charging station (FCS) that uses direct current (DC) based on a photovoltaic (PV) system, have the potential to effectively alleviate carbon emission and reduce significantly, if not completely do away with, the stress of the grid. However, such as FCS is not able to adequately address the high cost of the energy storage system (ESS) and the low utilization of the grid-connected interlinking converters (GIC) (Cheng, *et al*., 2021) [1]. Irrespective of the fact that the DC fast charging station possess the capability of increasing the rate of charging and extending the EVs mileage, it increases the stress while creating new challenges for the utility grid. Therefore, the DC FCS based on a photovoltaic (PV) system can be employed for the alleviation of the stress of the grid and the reduction of carbon emissions (Yan, Zhang, & Kezunovic, 2019) [26]. Smart Charging Algorithm of SCA has a self-regulated algorithm (SRA) that is specific to EVs and a grid-regulated algorithm (GRA) that is specific to GICs. While the change in DC bus voltage resulting from the fluctuations in power does not go beyond the established threshold, SRA readjusts the charging power of individual EV using the status of the charging (SOC) feedback of the EV, which again has the capacity to make sure the power rebalancing of the FCS. Once the DC bus voltage crosses this established threshold range, the GRA will begin its participation in the adjustment process. Under the condition of ensuring the charging power of all EVs, a GRA based on adaptive droop control can improve the utilization rate of GICs (Cheng, *et al*., 2021) [1].

Smart charging technology is one of the important ways through which EVs can be made more attractive to businesses. Smart charging is an umbrella concept and takes in or covers every one of the intelligent functionalities that are particular to charging stations, makes it possible for the customers to exercise higher control over the ways in which they charge their cars and the timing of charging. For instance, smart charging provides the opportunity for the customers to charge their vehicles during those times of the day when electricity is cheaper, e.g. overnight. This implies that they are able to circumvent the peak time costs (Valarino, 2019) [20].

Linked to this smart charging technology is the Vehicle to Grid technology that makes drawing power from car batteries possible and then the same power can be fed back into the grid at times of the day when the car is not being used. Sale of this unused energy back to the grid creates the opportunity for the EV customers to produce an additional revenue stream for themselves that can occur simultaneously with the cost saving function of smart charging and hence prove to be financially viable (Valarino, 2019) [20]. It is, therefore, obvious that smart charging, while proving to be beneficial for the grid also creates income opportunity for the EV owners which is more like incentivizing the use of EVs. The EV owners now have two options – either use the excess energy themselves or exploit the storage capacity of the V2G systems and push the unutilized electricity back to the grid which allows the customers to participate in energy markets by sending it back to the grid, creating the scope for savings on energy costs alongside the generation of additional revenue. One of the major advantages of V2G chargers is that it can help businesses generate revenues by utilizing those vehicles that have hitherto been just another application of funds on their balance sheet. So, these assets now become sources of funds as well, generating and saving a significant sum of money every year.

AI Capabilities

One of the major challenges that is being faced by the users of electric vehicles and stakeholders is the lack of development of effective charging infrastructure. In this respect, artificial intelligence (AI) has emerged as the much-needed transformative force that is revolutionizing the manner in which we look at Electric Vehicle charging networks (Gupta, 2024) [6]. Many a times conventional At the heart of EV revolution is Artificial Intelligence or AI, which is not only reconceptualizing e-mobility but also enhancing the charging infrastructure for electric vehicles. Charging infrastructure faces drawbacks in terms of reliability, scalability, as well as user experience (Vidyutva, 2023) [21]. Restricted availability of or limited access to charging stations, long wait times, and the absence of optimized charging schedules pose significant challenges when it comes to extensive EV adoption. AI technologies, however, offer pioneering and advanced solutions for addressing the challenges faced in terms of charging infrastructure and drive effectiveness across the whole of the charging ecosystem (Gupta, 2024) [6].

AI plays a crucial role in the management of the bidirectional flow of electrical energy amongst electric vehicles and the power grid. It has the capability to determine the optimal times an electric vehicle can supply superfluous energy back to the power grid, and in the process help to stabilize the grid during time when the power demand is at its peak or at those times when there are fluctuations in renewable energy (Vidyutva, 2023) [21]. AI-driven predictive analytics have a very important part to play in the optimization of placement and distribution of charging stations. Through the analysis of data on commuter behavior, geographic features, and traffic patterns, AI algorithms can find out the best locations for charging stations. This is particularly helpful for urban planners and infrastructure developers since these insights helps to strategically deploy charging infrastructure in places where these infrastructures are needed the most. This in turn helps to make sure that the EV users have convenient access to charging resources and that the resources are utilized to their fullest (Gupta, 2024) [6].

AI-driven innovations are prolific as of now and they are keeping the ambit of electric vehicles and EV charging is busy thus making the changeover to electric mobility a smoother process with higher mass appeal. Sustainability is the key work and AI is slowly making its way to being the indispensable option to achieve sustainability. The mixing of AI technology with V2G technology is not simply a step in the direction of achieving operational efficiency but a significant leap towards achieving sustainability, fostering an eco-friendly transportation ecosystem that will be user-centric (Vidyutva, 2023) [21]. The rise of AI therefore will have positive implications when it comes to V2G integration. For instance, AI systems are being developed for managing the bi-directional flow of energy between the grid and electric vehicles, which ensures both reliability and stability of the power supply. This gives rise to novel opportunities for the owners of electric vehicles to monetize their vehicles through their participation in the energy markets, which ultimately makes owning an EV a less costly affair as the initial outgo on EV starts getting partially offset by the income from sending power back to the grid (Elmelin Marketing, 2023) [4].

AI is not an essential element for V2G to function - it is just a matter of electrical engineering. However, AI is likely to be an integral part of making the implementation of V2G technology practically workable (Tahir & Gannatti, 2023) [17]. From the point of view of the consumers, AI will assist in optimizing the timing and enormity of transfer of energy between the power grid and the EVs. This will involve direction in relation to the amounts that the consumer should charge, the timings of retaining charge and when they should push the charge back to the grids and by what volume. This optimization is also expected to consider the consumption patterns of the users to make sure that the battery is always adequately charged to cater to road journeys needs of the consumer and any superfluous energy is sold back to the grid. AI systems can also improve battery lives. These systems are capable of monitoring and predicting the health and performance of the EV battery and in turn encourages proactive maintenance which helps to improve their longevity and reliability (Tahir & Gannatti, 2023) [17]. From the point of view of the grid, V2G adds to the list of variables to consider along with such aspects as weather types, which is a factor determining the extent of power generation using renewables. In this case, the consumption patterns user not only needs to be identified but also predicted for better management of demand and supply. Today, it has become absolutely necessary for the grid operators to match demand patterns that are rationally predictable, with the supply. Once the consumers get incorporated into the supply mix, it is likely to become difficult to predict the supply which will actually increase the significance of the role played by AI systems in predicting demand and supply (Tahir & Gannatti, 2023) [17].

Conclusion

It has already been highlighted several times throughout this article that the concept of Vehicle-to-Grid or V2G technology is unique and innovative where EVs are not simply vehicles that consume only electricity but they are also posed as the potential suppliers of electrical energy. Electric vehicles that are V2G enables will make MAAS (mobility as a service) possible which in turn will assist in the generation of efficient low carbon transport that would be preferred mode of commutation for both rural and urban populace. Beyond a doubt, V2G is an exciting emerging technology contained by the battery value chain. This novel technology allows the EV owners to treat their EVs like huge mobile batteries while also providing them the opportunities to earn from it. Rather than using the vehicle only for the purpose of drawing power from the grid and being mobile, V2G enables the users to also give the unused power, partly or wholly, back to the grid, which creates what is referred to as "bidirectional charging". Thanks to developing technologies in this segment that allow nearly accurate demand and supply prediction, V2G can be used as an effective way to address the problems associated with peak hour high demand for electricity and supply shortfall.

The EV universe is undergoing significant upheaval on account of continuous technological innovations. The industry is still nascent with significant scope for all-round development - from vehicle models to charging infrastructure and technology. Change is a constant factor in terms of the EV ecosystem they operate in, batteries and other aspects. Every segment of the industry is pursuing exhilarating innovations and significant changes are on the anvil, especially in the way EVs are powered and how they affect modern consumers' lives and the global environment. In case of investors, there exist significantly wide array of potential opportunities. They could gain exposure to the same by adopting a diversified approach that spans across the entire EV battery value chain. A part of the emerging technologies in EV is this V2G technology which hold a lot of promise in empowering the consumers. Through the application of technologies such as smart changing and AI, V2G can result in handling peak time power crisis as also be prepared for likely future demand surge. The new technologies are also aimed at making the EVs more economical. However, there still remains significant under-implementation emerging technologies due to various reasons including lack of funding or incentives and inadequate infrastructure. A detailed study could be carried out in this direction.

References

1. Cheng Q, Chen L, Sun Q, Wang R, Ma D, Qin D. A Smart Charging Algorithm Based on a Fast Charging Station Without Energy Storage System. CSEE Journal of Power and Energy Systems. 2021; 7(4):850-861. Available from: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9171658
2. CORINEX. V2G is the key to sustainable mobility and energy transition [Internet]. 2024 [cited 2024 Mar 14]. Available from: https://www.corinex.com/vehicle-to-grid
3. Dubarry M, Devie A, McKenzie K. Durability and reliability of electric vehicle batteries under electric utility grid operations: Bidirectional charging impact analysis. Journal of Power Sources. 2017; 358:39-49. Available from: https://doi.org/10.1016/j.jpowsour.2017.05.015
4. Elmelin Marketing. How AI in electric vehicles can transform battery charging [Internet]. 2023 Oct 11 [cited 2024 Mar 14]. Available from: https://elmelin.com/how-ai-in-electric-vehicles-can-transform-battery-charging/
5. Ghofrani M, Detert E, Hosseini NN, Arabali A, Myers N, Ngin P. V2G Services for Renewable Integration. In: Fakhfakh MA, editor. Modeling and Simulation for Electric Vehicle Applications. CBS Publishers & Distributors Pvt. Ltd; 2016 Oct 05. Available from: https://www.intechopen.com/chapters/51695
6. Gupta M. Driving Efficiency: Exploring AI's Impact on Electric Vehicle Charging Infrastructure. EMOBILITY+. 2024 Feb 16. Available from: https://emobilityplus.com/2024/02/16/driving-efficiency-exploring-ais-impact-on-electric-vehicle-charging-infrastructure/
7. Hive Power. The Future of V2G Technology: What to Expect in the Next Ten Years [Internet]. 2021 Jul 12 [cited 2024 Mar 11]. Available from: https://www.hivepower.tech/blog/the-future-of-v2g-technology-what-to-expect-in-the-next-ten-years
8. IEA. Smart grids - International Energy Agency (IEA) [Internet]. 2023 Jul 11 [cited 2024 Mar 13]. Available from: https://www.iea.org/energy-system/electricity/smart-grids
9. Khalid MS, Lin X, Zhuo Y, Kumar R, Rafique MK. Impact of Energy Management of Electric Vehicles on Transient Voltage Stability of Microgrid. World Electric Vehicle Journal. 2015; 7(4):577-588. Available from: https://doi.org/10.3390/wevj7040577
10. Kumar A. EVs as Virtual Power Plants (VPP) [Internet]. 2023 Mar 20 [cited 2024 Mar 08]. Available from: https://www.linkedin.com/pulse/evs-virtual-power-plants-vpp-aniket-kumar-anik-#:~:text=The%20use%20of%20EVs%20as%20a%20VPP%20offers%20a%20promising,services%20to%20the%20electrical%20grid.
11. Kumar A. Revolutionizing Energy Distribution: Exploring the Potential of Vehicle-to-Grid (V2G) Technology [Internet]. 2023 Jul 10 [cited 2024 Mar 05]. Available from: https://www.linkedin.com/pulse/revolutionizing-energy-distribution-exploring-v2g-aniket-kumar-anik-
12. Mojumder MH, Antara FA, Hasanuzzaman Md, Alamri B, Alsharef M. Electric Vehicle-to-Grid (V2G) Technologies: Impact on the Power Grid and Battery. Sustainability. 2022; 14(21). Available from: https://doi.org/10.3390/su142113856
13. Ravi SS, Aziz M. Utilization of Electric Vehicles for Vehicle-to-Grid Services: Progress and Perspectives. Energies. 2022; 15(2):1-27. Available from: https://doi.org/10.3390/en15020589
14. Servotech Power. Everything You Need to Know about Vehicle-to-Grid (V2G) Technology [Internet]. 2023 Nov 07 [cited 2024 Mar 07]. Available from:

https://www.servotech.in/blog/know-about-vehicle-to-grid-technology/
15. Shariff SM, Iqbal D, Alam M, Ahmad F. State of the Art Review of Electric Vehicle to Grid (V2G) technology. IOP Conference Series: Materials Science and Engineering. 2019; 561:1-6. Available from: https://doi.org/10.1088/1755-1315/561/1/012070
16. Sinha RK. Vehicle to Grid (V2G) Technology and Way Ahead. Acquity. 2023 Oct 17. Available from: https://www.acuitykp.com/blog/vehicle-to-grid-technology-and-way-ahead/
17. Tahir M, Gannatti C. Could AI Turn EVs into Money-Making Machines? WisdomTree. 2023 Dec 12. Available from: https://www.wisdomtree.com/investments/blog/2023/07/12/could-ai-turn-evs-into-money-making-machines
18. Uddin K, Dubarry M, Glick MB. The viability of vehicle-to-grid operations from a battery technology and policy perspective. Energy Policy. 2018; 113:342-347. Available from: https://doi.org/10.1016/j.enpol.2017.11.015
19. Umair M, Hidayat NM, Ali N, Abdullah E, Johari AR, Hakomori T. The effect of vehicle-to-grid integration on power. 6th International Conference on Clean Energy and Technology 2023: IOP Conf. Series: Earth and Environmental Science. 2023; 1281:1-8. Available from: https://iopscience.iop.org/article/10.1088/1755-1315/1281/1/012070/pdf
20. Valarino P. Sustainability: V2G: charging towards a greener future. Energy Digital. 2019 Nov 03. Available from: https://energydigital.com/sustainability/v2g-charging-towards-greener-future
21. Vidyutva. Igniting Electric Highways: The Role of AI in Electric Vehicles and EV Charging. LinkedIn. 2023 Oct 17. Available from: https://www.linkedin.com/pulse/igniting-electric-highways-role-ai-vehicles-ev-charging-vidyutva/
22. Vitra Global. Vehicle-To-Grid (V2G): Everything You Need To Know [Internet]. 2023 [cited 2024 Mar 07]. Available from: https://www.virta.global/vehicle-to-grid-v2g#:~:text=With%20V2G%20technology%2C%20an%20EV,back%20to%20the%20power%20grid.
23. Wang J, Guo C, Yu C, Liang Y. Virtual power plant containing electric vehicles scheduling strategies based on deep reinforcement learning. Electric Power Systems Research. 2022; 205. Available from: https://doi.org/10.1016/j.epsr.2021.107714
24. Wang Q, Liu X, Du J, Kong F. Smart Charging for Electric Vehicles: A Survey From the Algorithmic Perspective. IEEE Communications Surveys & Tutorials. 2016; 18(02):1500-1517.
25. Wenzel E. Vehicle-to-grid technology is revving up. GreenBiz. 2019 Nov 12. Available from: https://www.greenbiz.com/article/vehicle-grid-technology-revving
26. Yan Q, Zhang B, Kezunovic M. Optimized operational cost reduction for an EV charging station integrated with battery energy storage and PV generation. IEEE Transactions on Smart Grid. 2019; 10(2):2096-2106.
27. Zheng Y, Jian L. Smart charging algorithm of electric vehicles considering dynamic charging priority. In: IEEE International Conference on Information and Automation (ICIA). Ningbo, China: IEEE; 2016. doi:10.1109/ICInfA.2016.7831884